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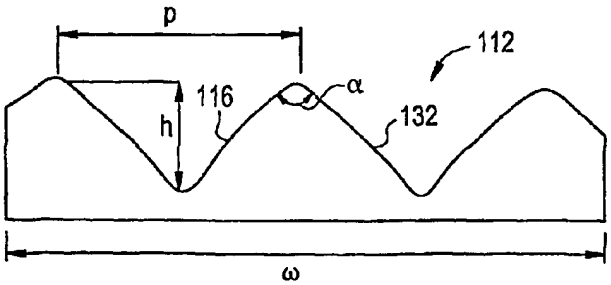
(54) Title: BRIGHTNESS ENHANCEMENT FILM WITH IMPROVED VIEW ANGLE



(57) Abstract: A structural shape on the surface of an optical substrate (110) is such that the brightness of diffuse light departing from the surface of the optical substrate (110) at certain off axis angles is reduced, at the expense of a small reduction in peak brightness measured near the viewing axis. The net result is an overall increase in useful illumination. A cross section of a prism as the structural shape has a curved sidewall or facet. A material with a relatively high index of refraction combined with a prismatic structure having a modified prism geometry improves brightness.

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BRIGHTNESS ENHANCEMENT FILM WITH IMPROVED VIEW ANGLE

BACKGROUND OF THE INVENTION

This invention relates to brightness enhancement films and, more specifically to such films having curved facet prism structures and increased prism peak angles and refractive indices.

In backlight computer displays or other systems, optical films are commonly used to direct light. For example, in backlight displays, brightness enhancement films use prismatic structures to direct light along the viewing axis (i.e., an axis normal to the display, or "on axis"). This enhances the brightness of the light viewed by the user of the display and allows the system to use less power to create a desired level of on-axis illumination. Films for turning light can also be used in a wide range of other optical designs, such as for projection displays, traffic signals, and illuminated signs.

Backlight displays and other systems use layers of films stacked and arranged so that the prismatic surfaces thereof are perpendicular to one another and are sandwiched between other optical films known as diffusers. Diffusers have highly irregular surfaces.

The use of current commercial brightness enhancement films causes a sharp cut-off in brightness between about 40 and 50 degrees off-axis. At angles beyond this cut-off there are side-lobes in the angular brightness distribution. These side-lobes can result in a waste of energy because they are outside the desired viewing angle specifications of many liquid crystal display (LCD) devices. The side-lobes are also undesirable in security applications since they allow light to reach unintended viewers.

Thus, there is a continuing and demonstrated need in the prior art for brightness enhancement films which suppress sidelobes in the angular distribution of brightness.

SUMMARY OF THE INVENTION

In a first embodiment, the invention features a structural shape for the surface of an optical substrate such that the brightness of diffuse light departing from the surface of the optical substrate at certain off axis angles is reduced, at the expense of a small reduction in peak brightness measured near the viewing axis. The net result is an overall increase in useful illumination. Such an optical substrate comprises a surface characterized by a cross section of at least one prism having a curved sidewall or facet.

In a second embodiment, the invention features a combination of a high index of refraction prismatic structure with a modified prism geometry. Brightness performance is met or exceeded, for example in an LCD back light display device, when the index of refraction of the prism structure is increased to a value above the index of refraction of materials commonly used in brightness enhancement films, while the peak angle is allowed to increase beyond 90 degrees.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a cross sectional view of a backlight display device.

FIGURE 2 is a perspective view of an optical substrate comprising a surface characterized by a cross section of a prism having a curved sidewall or facet.

FIGURE 3 is a first cross sectional view of an optical substrate comprising a surface characterized by a cross section of a prism having a curved sidewall or facet.

FIGURE 4 is a second cross sectional view of an optical substrate comprising a surface characterized by a cross section of a prism having a curved sidewall or facet.

FIGURE 5 is a graphical depiction of brightness as a function of horizontal viewing angle for an optical substrate comprising a surface characterized first by a cross section of a right angle prism, second by the curved sidewall or facet in Figure 3 and third by the curved sidewall or facet in Figure 4.

FIGURE 6 is a cross sectional view of a compound angle prism and of the geometric parameters of the curved sidewall or facet of Figures 3 and 4 as described by a segment of a polynomial function.

FIGURE 7 is a perspective view of two optical substrates positioned in a crossed configuration wherein prismatic structures are positioned at an angle with respect to one another (e.g., 90 degrees).

FIGURE 8 is a map of the central luminance of crossed optical substrates as a function of the prism peak angle and the refractive index of the substrate.

FIGURE 9 is a graphical depiction of the far field horizontal luminance of crossed optical substrates as a function of horizontal viewing angle.

FIGURE 10 is a graphical depiction of the far field vertical luminance of crossed optical substrates as a function of vertical viewing angle.

FIGURE 11 is a graphical depiction of the far field horizontal luminance of crossed optical substrates as a function of horizontal viewing angle.

FIGURE 12 is a graphical depiction of the far field vertical luminance of crossed optical substrates as a function of vertical viewing angle.

DETAILED DESCRIPTION OF THE INVENTION

In Figure 1 a cross sectional view of a backlight display device 100 is shown. The backlight display device 100 comprises an optical source 102 for generating light 104. A light guide 106 guides the light 104 therealong by total internal reflection (TIR). The light guide 106 contains disruptive features that cause the light 104 to escape the light guide 106. A reflective substrate 108 positioned along the lower surface of the light guide 106 reflects any light 104 escaping from the lower surface of the light guide 106 back through the light guide 106 and toward an optical substrate 110. At least one optical substrate 110 is receptive of the light 104 from the light guide 106. The optical substrates 110 comprise a three-dimensional surface 112 defined by prismatic structures 116 (Figs. 2, 3 and 4).

The optical substrates 110 may be positioned, one above the other, in a crossed configuration wherein the prismatic structures 116 are positioned at an angle with respect to one another (e.g., 90 degrees) as seen in Figure 7. The prisms 116 have a prescribed peak angle, α, a height, h, a length, l, and a pitch, p and one or both of the prismatic surfaces 112 may be randomized in their peak angle, α, height, h, length, l, and pitch, p. Yet further, one or both sides of the substrates 110 may have the prisms 116. In Figures 2, 3 and 4, in a first embodiment of the invention, the sidewall or facets 132 of the prisms 116 which comprise the surface 112 are curved. The curvature can be described as a segment of a parabola, or more generally as a polynomial surface given by the sag equation:

$$z = \frac{cr^2}{1+\sqrt{1-(1+k)c^2r^2}} + dr^2 + er^4 + fr^6 + \textit{Higher order terms in } r \qquad (1)$$

where z is the perpendicular deviation (or "sag") in microns of the sidewall or facet 132 of the prisms 116 from a straight reference line 128, originating at a first reference point (b) at a base of the prism and terminating at a second reference point (a) near the peak of the prism (see Figure 6) and c^{-1} is the radius of curvature of the facet. Here the coefficients of the polynomial may have the following approximate ranges: $-20 < c < 20$, $-10 < d < 10$, $-10 < e < 10$, $-10 < f < 10$, and $-1 < k$ or less than or equal to zero, wherein r is a radial coordinate or distance from an optical axis in microns. It is noted that c^2r^2 is greater than or equal to zero and less than or equal to 1. Odd order terms in r (e.g., r^1, r^3, r^5, r^7, etc.) with appropriately chosen coefficients may also be used as in Eq. 1. The higher order terms for the even and odd order terms have appropriately chosen coefficients. Terms other than the first r^2 term may be written as: $\sum_{i=1}^{N} a_i r^i$.

Linear segments 124, 126 or other approximations to the polynomial described by Eq. 1 may also be used as seen in Figure 6. Linear segments 124, 126 result in a compound angle prism having a first facet 126 at an angle of θ and a second facet 124 at an angle of β. As best understood from Figure 6, the curvature of the curved sidewall or facet 132 of the prisms 116 can be either convex or concave. In Figure 6,

the side facets of the prism are positioned so as to form one or more compound facets 124, 126, respectively subtending an angle of β or θ with the base of the prism.

Sample cross sections of the prisms 116, over a width w, are shown is Figures 2, 3 and 4. Figure 5 is a graphical depiction of brightness as a function of horizontal viewing angle for an optical substrate comprising a surface characterized first 118 by a cross section of a right angled, straight-sided prism, second 122 by the curved sidewall or facet in Figure 3, and third 120 by the curved sidewall or facet in Figure 4. As can be seen in Figure 5, for a right angled, straight-sided prism 118 the brightness shows significant side lobes 128, 130 at a horizontal view angle of approximately +/- 50 degrees. These sidelobes are not seen in either of the curved faceted prisms of Figures 3 and 4. However, there is a slight reduction in overall brightness for the curved prisms. As seen by comparing graph 122 with graph 120 in Figure 5, for a refractive index of approximately 1.6 in the optical substrate the steeper the curvature of the side wall the greater the reduction in overall brightness. Also, as seen in Figure 5, as the curvature of the facets increases away from the straight wall of a 90 degree prism, the wider is the central lobe and the lower is the central luminance and the sidelobes.

In a second embodiment, a relatively high index of refraction for the optical substrate 110 in combination with a modified prism geometry yields an enhanced brightness. In particular, Figure 8 displays a map of the central luminance in per cent of crossed optical substrates as a function of the prism peak angle and the refractive index of the substrate, wherein a refractive index of 1.6 and a peak angle of 90 degrees is taken to be 100 per cent. By increasing the peak angle to 100 degrees and increasing the refractive index of the optical substrate generally to greater than about 1.65 and in particular to between approximately 1.7 and 1.8, the luminance is at least 102 per cent.

Figure 9 shows a graphical depiction of the far field horizontal luminance of crossed optical substrates as a function of horizontal viewing angle. In Figure 9, a prior art luminance profile, based upon a refractive index of 1.65 and a peak prism angle of 90 degrees is shown at 150. As can be seen in Figure 9, the prior art shows sidelobes at

152. By increasing the refractive index of the substrates to about 1.75 and the peak prism angle to about 100 degrees, as seen at 154, the central portion of the luminance profile (e.g. +/- 30 degrees) displays a higher peak luminance (about 118) with essentially no sidelobes 156.

Similarly, Figure 10 shows a graphical depiction of the far field vertical luminance of crossed optical substrates as a function of vertical viewing angle. In Figure 10, a prior art luminance profile, based upon a refractive index of 1.65 and a peak prism angle of 90 degrees is shown at 158. As can be seen in Figure 10, the prior art shows sidelobes at 160. By increasing the refractive index of the substrates to about 1.75 and the peak prism angle to about 100 degrees, as seen at 162, the central portion of the luminance profile (e.g. +/- 30 degrees) displays a higher peak luminance (about 118) with suppressed sidelobes 164.

Figure 11 shows a graphical depiction of the far field horizontal luminance of crossed optical substrates as a function of horizontal viewing angle. In Figure 11, a prior art luminance profile, based upon a refractive index of 1.60 and a peak prism angle of 90 degrees is shown at 166. As can be seen in Figure 11, the prior art shows sidelobes at 168. As further seen at 170 in Figure 11, by increasing the peak angle from 90 degrees to about 100 degrees while keeping the refractive index of the substrate at 1.60, the sidelobes 172 are reduced slightly while the central segment of the luminance is only slightly less. Still further, by increasing the refractive index of the substrates to about 1.75 and the peak prism angle to about 100 degrees, as seen at 174, the central portion of the luminance profile (e.g. +/- 30 degrees) displays a slightly higher peak luminance (about 105) with slightly lower sidelobes 176.

Similarly, Figure 12 shows a graphical depiction of the far field vertical luminance of crossed optical substrates as a function of vertical viewing angle. In Figure 12, a prior art luminance profile, based upon a refractive index of 1.60 and a peak prism angle of 90 degrees is shown at 178. As can be seen in Figure 12, the prior art shows sidelobes at 180. As further seen at 182 in Figure 12, by increasing the peak angle from 90 degrees to about 100 degrees while keeping the refractive index of the substrate at 1.60, the sidelobes 184 are reduced while the central segment of the

luminance is only slightly less. Still further, by increasing the refractive index of the substrates to about 1.75 and the peak prism angle to about 100 degrees, as seen at 186, the central portion of the luminance profile (e.g. +/- 30 degrees) displays a higher peak luminance (about 105) with slightly lower sidelobes 188.

Thus, it can be seen from Figures 8 – 12 that by increasing the refractive index of the substrate 110 and/or by increasing the peak angle, α, of the prism structures 116, an improvement is realized in an increase in the on-axis luminance of the optical substrate 110 as well as a reduction in the energy sidelobes of the horizontal and vertical luminance profile.

The optical substrate 110 may be formed from an optically transparent polymer, an ultraviolet (UV) curable organic or inorganic material (or hybrid thereof). In such an optical substrate 110, an index of refraction of greater than about 1.65 is preferred.

Aside from the use of the optical substrates 110 described above in backlight displays for brightness enhancement, the substrates can be used in a wide variety of other applications as well. Embodiments of the substrates 110 can be used in Fresnel lenses, hybrid glass/plastic lenses, optical disks, diffuser films, holographic substrates or in combination with conventional lenses, prisms or mirrors. Such embodiments could be formed by modulating concentric circles or ellipses having fixed characteristics. The optical substrates can also be used in single or multi-order reflective, transmissive or partially transmissive, devices, whether light absorbing or non light absorbing; prisms, holographic optical elements, or diffraction gratings. The substrates can be used in other applications such as projection displays, illuminated signs, and traffic signals. Another property of the invention is that the curved (or compound angle) facets increase the blurring of the light guide features. This is an advantage since it enhances the visual appearance of the display.

Any references to first, second, etc., or front and back, right and left, top and bottom, upper and lower, and horizontal and vertical or any other phrase relating one variable or quantity to another are, unless noted otherwise, intended for the convenience of the description of the invention, and are not intended to limit the present invention or

its components to any one positional or spatial orientation. All dimensions of the components in the attached Figures can vary with a potential design and the intended use of an embodiment without departing from the scope of the invention.

While the invention has been described with reference to several embodiments thereof, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiments disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

CLAIMS

1. An optical substrate (110) comprising:

a surface (112) comprising a prism structure (116) characterized by a cross section having a curved facet described by the equation

$$z = \frac{cr^2}{1+\sqrt{1-(1+k)c^2r^2}} + dr^2 + er^4 + fr^6,$$

wherein z is the perpendicular deviation of the surface (112) of the facet of the prism (116) from a straight line originating at a first reference point and terminating at a second reference point and the coefficients of the polynomial lie within the following approximate ranges: $-20 < c < 20$; $-10 < d < 10$; $-10 < e < 10$; $-10 < f < 10$ and $-1 < k$ is less than or equal to zero and where r is a radial coordinate or distance from an optical axis.

2. The optical substrate as set forth in Claim 1 wherein the prism structure (116) comprises a plurality of prisms having a prescribed peak angle, α, a height, h, a length, l, and a pitch, p.

3. The optical substrate as set forth in Claim 2 wherein the plurality of prisms (116) include at least a pseudorandom peak angle, α, height, h, length, l, and pitch, p.

4. The optical substrate as set forth in Claim 1 wherein a peak angle of the prism (116) is greater than 90 degrees and the refractive index of the substrate is between approximately 1.65 and 1.8.

5. The optical substrate as set forth in Claim 4 wherein the peak angle is 100 degrees.

6. An optical substrate (110) comprising:

a surface comprising a prism structure (116) characterized by a peak angle of greater than 90 degrees and a refractive index of between approximately 1.65 and 1.8.

7. The optical substrate (110) as set forth in Claim 6 wherein the peak angle is 100 degrees.

8. A backlight display device (100) comprising:

an optical source (102) for generating light (104);

a light guide (106) for guiding the light (104) therealong including a reflective device (108) positioned along the light guide (106) for reflecting the light (104) out of the light guide (106);

an optical substrate (110) receptive of the light (104) from the reflective device (108), the optical substrate (110) comprising:

a surface comprising a prism structure (116) characterized by a cross section having a curved facet.

9. The backlight display device as set forth in Claim 8 wherein the curved facet is described by a segment of a polynomial function.

10. The backlight display device as set forth in Claim 8 wherein the segment of the polynomial function is described by the equation

$$z = \frac{cr^2}{1+\sqrt{1-(1+k)c^2r^2}} + dr^2 + er^4 + fr^6,$$

wherein z is the perpendicular deviation of the surface of the facet of the prism from a straight line originating at a first reference point and terminating at a second reference point and the coefficients of the polynomial lie within the following approximate ranges: $-20 < c < 20$; $-10 < d < 10$; $-10 < e < 10$; $-10 < f < 10$ and $-1 < k$ is less than or equal to zero and where r is a radial coordinate or distance from an optical axis.

11. The backlight display device (100) as set forth in Claim 8 wherein a peak angle of the prism is greater than 90 degrees and the refractive index of the substrate is between approximately 1.65 and 1.8.

12. The backlight display device as set forth in Claim 11 wherein the peak angle is 100 degrees.

13. The backlight display device (100) as set forth in Claim 8 wherein the optical substrate (110) is formed with an optically transparent material with an index of refraction between approximately 1.65 and 1.8.

14. The backlight display device (100) as set forth in Claim 10 wherein the optical substrate (110) is formed with an optically transparent material with an index of refraction of approximately 1.75.

15. An optical substrate (110) comprising:

a surface (112) comprising a prism structure (116) characterized by a cross section having a plurality of facets including a first facet (126) oriented at a first angle with respect to the surface of the prism and a second facet (124) oriented at a second angle with respect to the surface of the prism;

wherein the first and second facets (124, 126) intersect at one side of a centerline of the prism and the first and second angles are different.

16. The optical substrate (110) as set forth in Claim 15 wherein a peak angle of the prism structure is greater than 90 degrees and the refractive index of the substrate is between approximately 1.65 and 1.8.

17. The optical substrate (110) as set forth in Claim 16 wherein the peak angle is 100 degrees.

18. The optical substrate (110) as set forth in Claim 1 wherein the prism structure (116) is an ultraviolet curable organic or inorganic material.

19. The optical substrate (110) as set forth in Claim 6 wherein the prism structure (116) is an ultraviolet curable organic or inorganic material.

20. The backlight display device (100) as set forth in Claim 8 wherein the prism structure is an ultraviolet curable organic or inorganic material.

21. The optical substrate (110) as set forth in Claim 15 wherein the prism structure (116) is an ultraviolet curable organic or inorganic material.

22. The optical substrate (110) as set forth in Claim 1 wherein the prism structure (116) includes a peak angle of greater than approximately 94 degrees and wherein c, d, e, f, and k are approximately equal to zero.

23. The optical substrate (110) as set forth in Claim 1 wherein the equation for z includes higher order terms in r defined by the summation $\sum_{i=1}^{N} a_i r^i$ where a_i are coefficients and N is an integer.

24. The optical substrate (110) as set forth in Claim 10 wherein the prism structure (116) includes a peak angle of greater than approximately 94 degrees and wherein c, d, e, f, and k are approximately equal to zero.

25. The optical substrate (110) as set forth in Claim 10 wherein the equation for z includes higher order terms in r defined by the summation $\sum_{i=1}^{N} a_i r^i$ where a_i are coefficients and N is an integer.

26. An optical substrate (110) comprising:

a surface comprising a prism structure (116) characterized by a cross section having a facet described by the equation

$$z = \frac{cr^2}{1+\sqrt{1-(1+k)c^2r^2}},$$

wherein z is the perpendicular deviation of the surface of the facet of the prism from a straight line originating at a first reference point and terminating at a second reference point.

27. The optical substrate (110) as set forth in Claim 26 wherein the equation further comprises a summation of higher order terms

$$+dr^2+er^4+fr^6$$

wherein the coefficients thereof lie within the following approximate ranges: $-20 < c < 20$; $-10 < d < 10$; $-10 < e < 10$; $-10 < f < 10$ and $-1 < k$ is less than or equal to zero and where r is a radial coordinate or distance from an optical axis.

28. An optical substrate (110) comprising:

a surface comprising a prism structure (116) characterized by a cross section having a plurality of facets intersecting at a peak so as to subtend a peak angle of α.

29. The optical substrate (110) as set forth in Claim 28 wherein the plurality of facets form one or more compound facets respectively subtending an angle of β or θ with a base of the prism.

FIG. 1

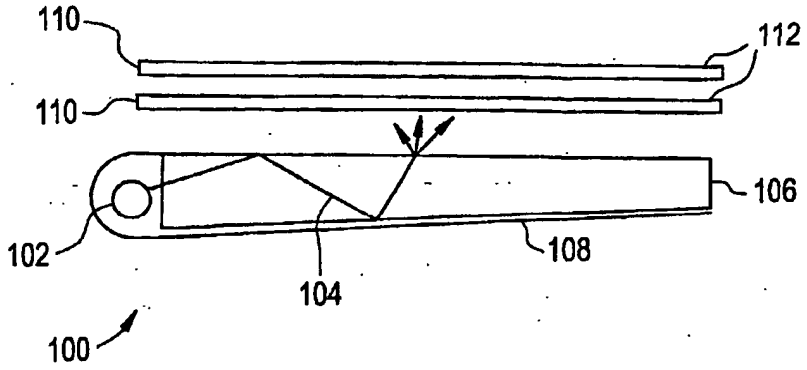


FIG. 2

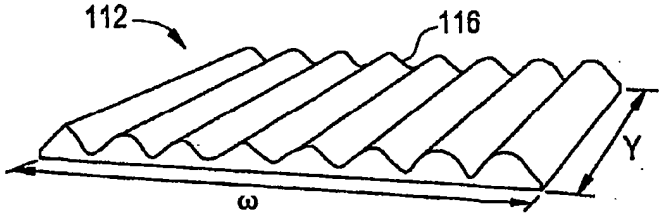


FIG. 3

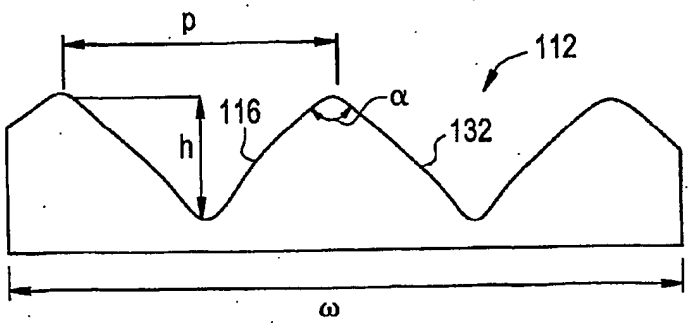


FIG. 4

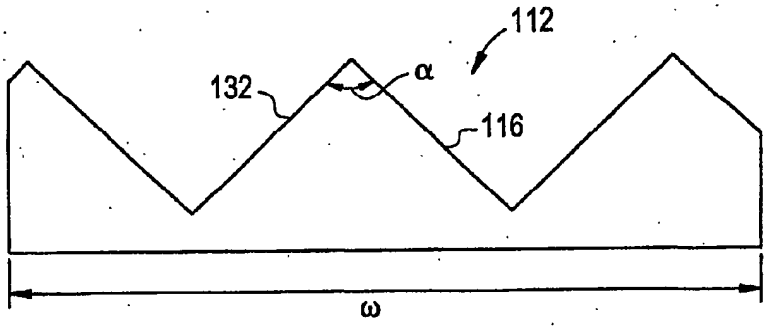

112
α
132
116
ω

FIG. 5

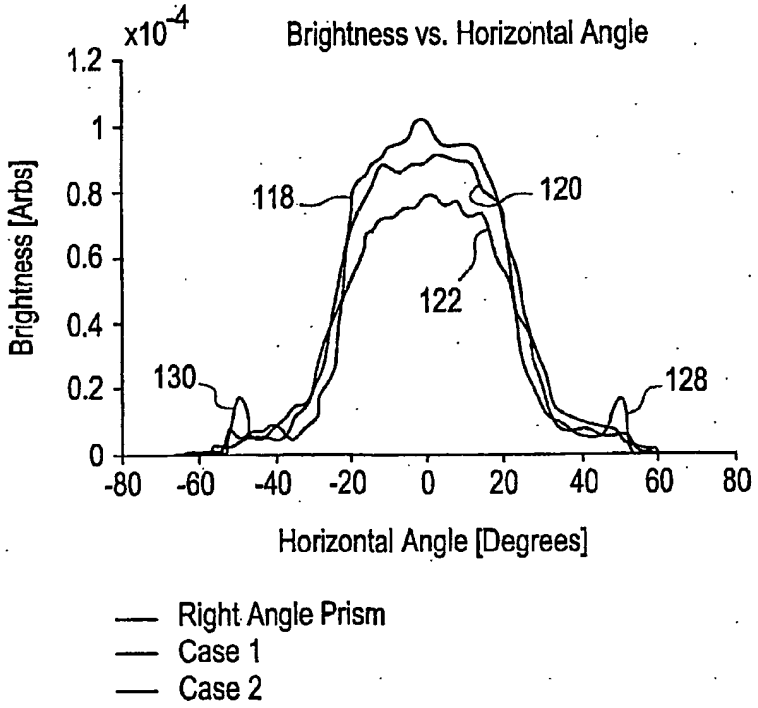

x10^-4
Brightness vs. Horizontal Angle
1.2
1
0.8
0.6
0.4
0.2
0
Brightness [Arbs]
118
120
122
130
128
-80
-60
-40
-20
0
20
40
60
80
Horizontal Angle [Degrees]
Right Angle Prism
Case 1
Case 2

FIG. 6

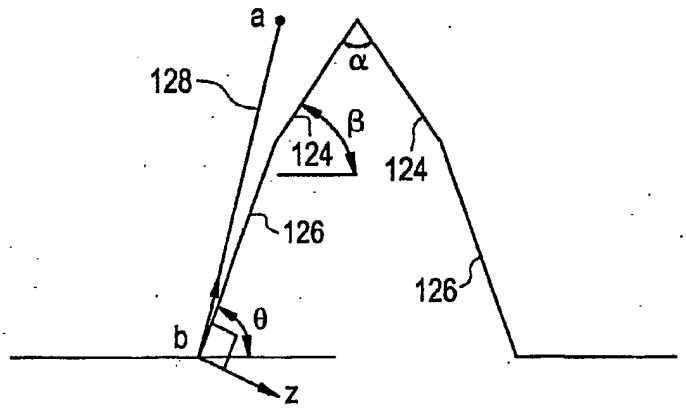


FIG. 7

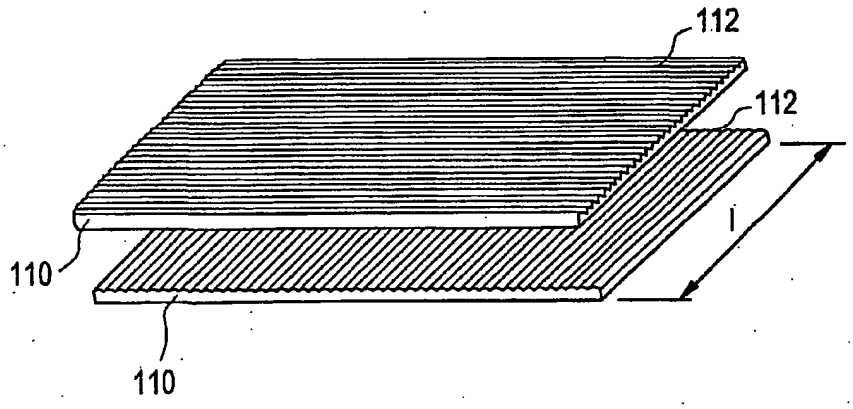


FIG. 8

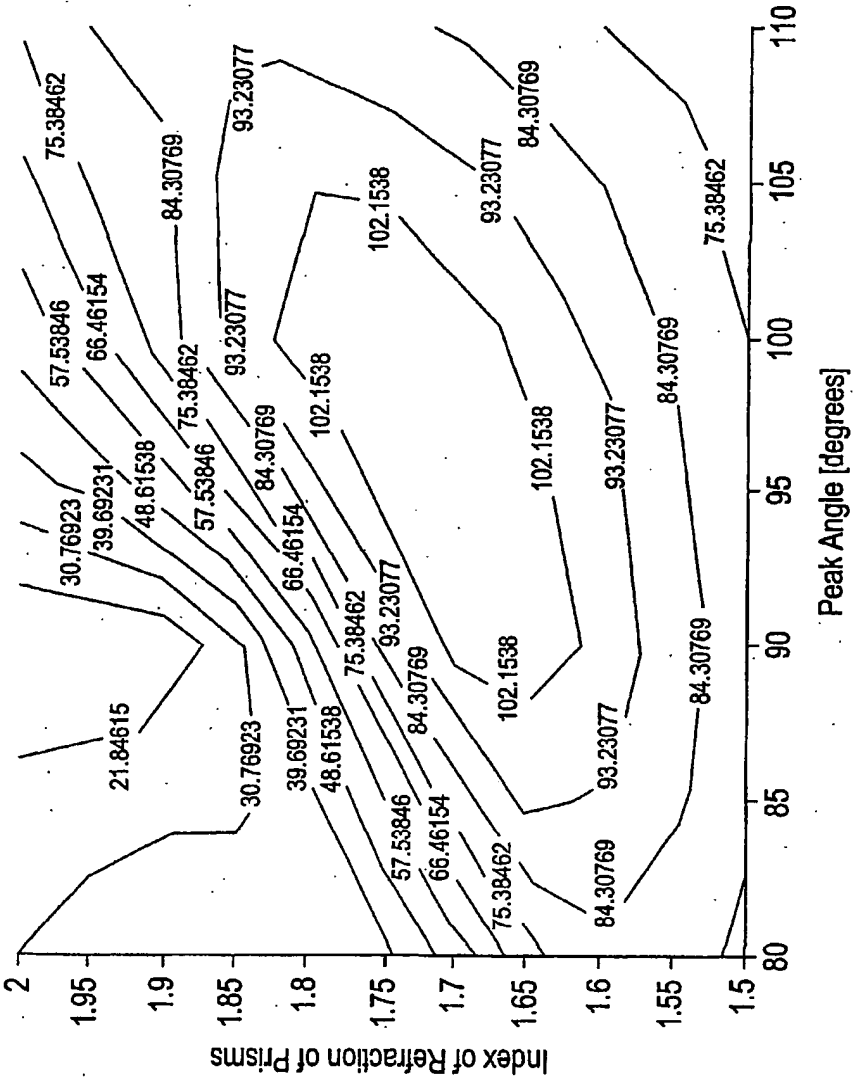

Index of Refraction of Prisms
Peak Angle [degrees]
2
1.95
1.9
1.85
1.8
1.75
1.7
1.65
1.6
1.55
1.5
80
85
90
95
100
105
110
21.84615
30.76923
39.69231
48.61538
57.53846
66.46154
75.38462
84.30769
93.23077
102.1538

FIG. 9

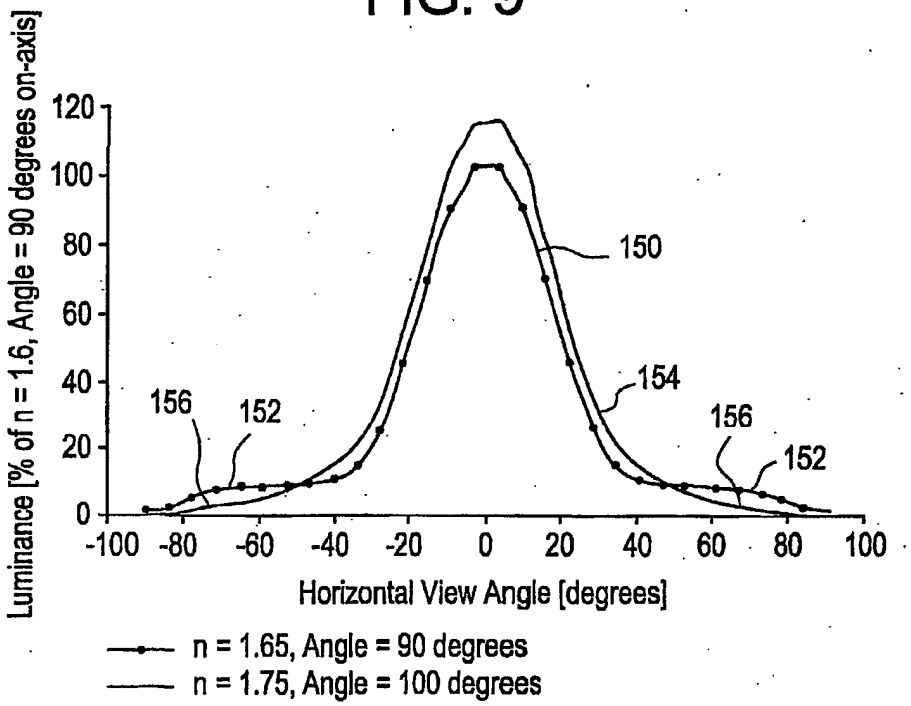

Luminance [% of n = 1.6, Angle = 90 degrees on-axis]
120
100
80
60
40
20
0
-100 -80 -60 -40 -20 0 20 40 60 80 100
Horizontal View Angle [degrees]
150
154
156
152
156
152
n = 1.65, Angle = 90 degrees
n = 1.75, Angle = 100 degrees

FIG. 10

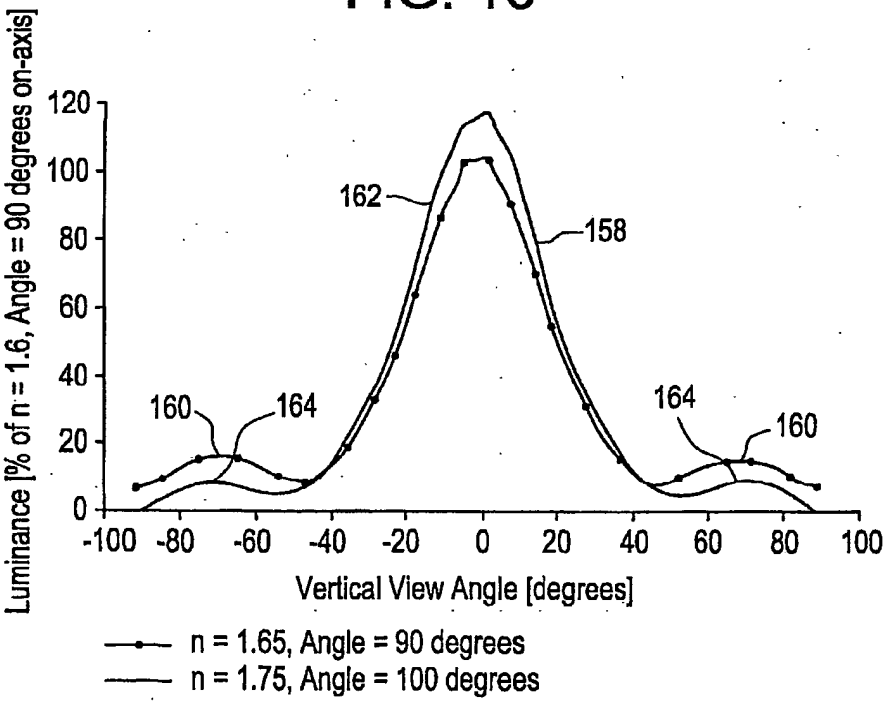

Luminance [% of n = 1.6, Angle = 90 degrees on-axis]
120
100
80
60
40
20
0
-100 -80 -60 -40 -20 0 20 40 60 80 100
Vertical View Angle [degrees]
162
158
160
164
164
160
n = 1.65, Angle = 90 degrees
n = 1.75, Angle = 100 degrees

FIG. 11

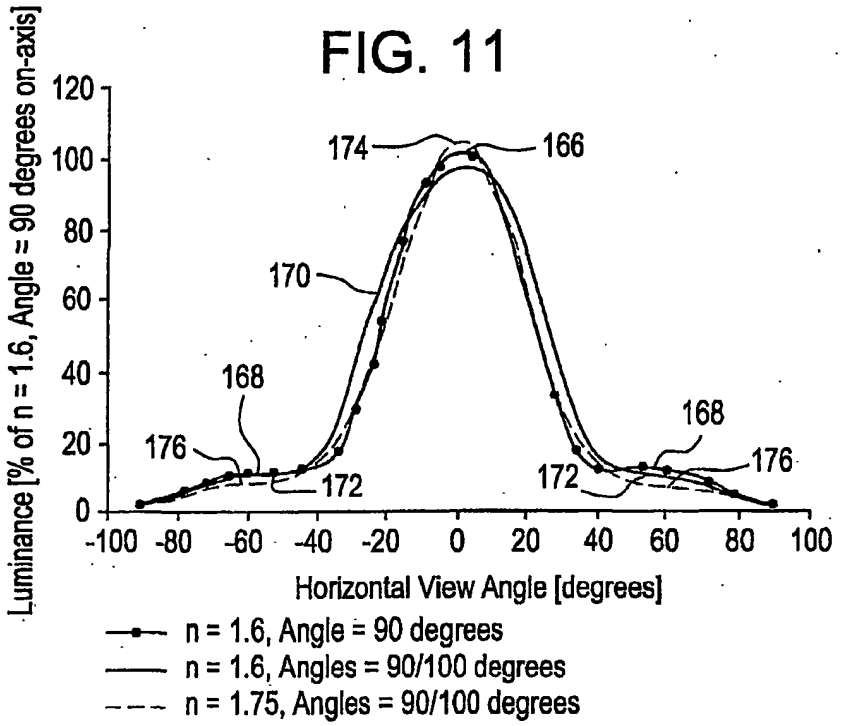
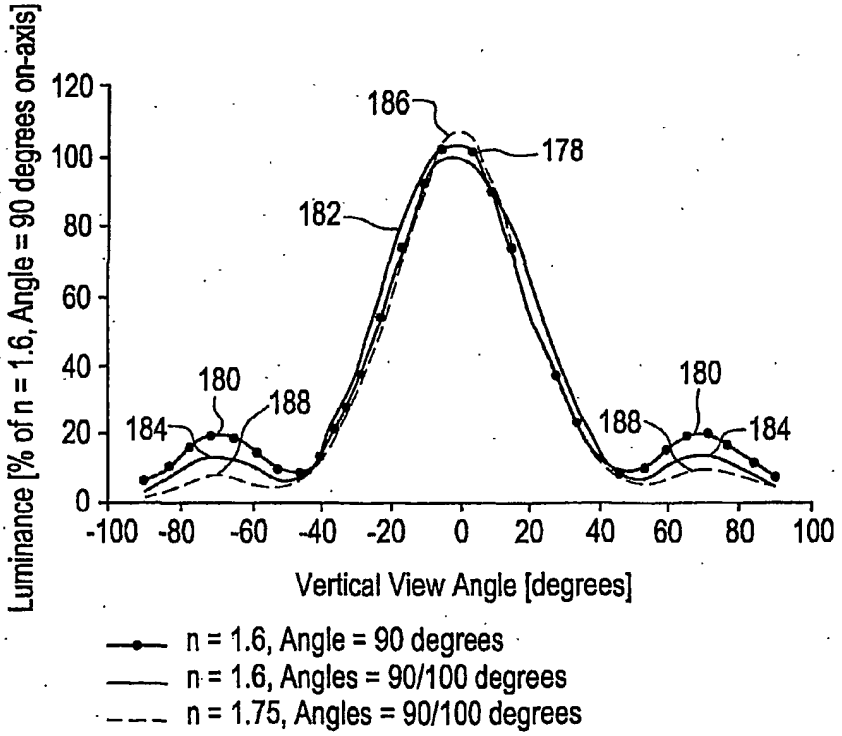

Luminance [% of n = 1.6, Angle = 90 degrees on-axis]
120
100
80
60
40
20
0
-100 -80 -60 -40 -20 0 20 40 60 80 100
Horizontal View Angle [degrees]
174
166
170
168
176
172
168
176
172
n = 1.6, Angle = 90 degrees
n = 1.6, Angles = 90/100 degrees
n = 1.75, Angles = 90/100 degrees

FIG. 12


Luminance [% of n = 1.6, Angle = 90 degrees on-axis]
120
100
80
60
40
20
0
-100 -80 -60 -40 -20 0 20 40 60 80 100
Vertical View Angle [degrees]
186
178
182
180
188
184
180
188
184
n = 1.6, Angle = 90 degrees
n = 1.6, Angles = 90/100 degrees
n = 1.75, Angles = 90/100 degrees

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(71) Applicant *(for all designated States except US)*: **GENERAL ELECTRIC COMPANY** [US/US]; 1 River Road, Schenectady, NY 12345 (US).

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(75) Inventor/Applicant *(for US only)*: **OLCZAK, Eugene** [US/US]; 2575 Johnson Road, Glenville, NY 12302 (US).

(74) Agents: **GNIBUS, Michael** et al.; Patent Counsel, General Electric Company, 3135 Easton Turnpike (W3C), Fairfield, CT 06828 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

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— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

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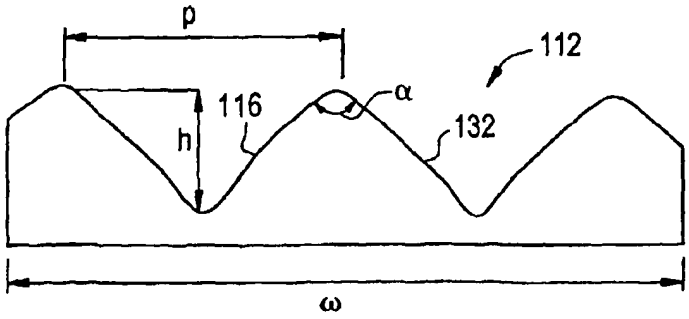
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: BRIGHTNESS ENHANCEMENT FILM WITH IMPROVED VIEW ANGLE



(57) Abstract: A structural shape on the surface of an optical substrate (110) is such that the brightness of diffuse light departing from the surface of the optical substrate (110) at certain off axis angles is reduced, at the expense of a small reduction in peak brightness measured near the viewing axis. The net result is an overall increase in useful illumination. A cross section of a prism as the structural shape has a curved sidewall or facet. A material with a relatively high index of refraction combined with a prismatic structure having a modified prism geometry improves brightness.

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 03/37059

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02B6/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2002/141060 A1 (JACOB DAVID A ET AL) 3 October 2002 (2002-10-03) paragraph '0048!; figures 4,8,10,11	1,2,28, 29
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
27 July 2004	-5. 08. 2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Hylla, W

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 03/37059

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 971 559 A (ISHIKAWA TSUYOSHI ET AL) 26 October 1999 (1999-10-26) abstract; figures 3,33 column 2, line 57 - column 3, line 4 column 3, line 55 - column 4, line 15	1,2,22, 26,27
X	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 08, 29 August 1997 (1997-08-29) -& JP 09 101520 A (SHIMURA KAKEN KOGYO KK), 15 April 1997 (1997-04-15) abstract; figures 4,12 paragraph '0013!	1,2,22, 26,27
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A	US 4 550 482 A (BUCKLEY GALEN L ET AL) 5 November 1985 (1985-11-05) column 1, line 7 - line 12; figures 4,8 column 8, line 11 - line 26; table I	10

INTERNATIONAL SEARCH REPORT

national application No.
PCT/US 03/37059

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☒ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

1-5, 8-14, 18, 20, 22-29

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-5,18,22,23,26-29

1.1. claims: 1-5,18,22,23,26,27

Optical substrate with a prism structure characterised by having a curved facet described by a polynomial sag equation

1.2. claims: 28,29

Optical substrate with a prism structure having a cross section comprising a plurality of facets intersecting at a peak to subtend a peak angle alpha

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2. claims: 6,7,19

Optical substrate with a prism structure characterised by a peak angle > 90° and having a refractive index between 1.65 and 1.8

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3. claims: 8-14,20,24,25

Backlight display device characterised by comprising, among other, an optical substrate with a prism structure having a curved facet

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4. claims: 15-17,21

Optical substrate with a prism structure characterised by the prism structure comprising two intersecting facets oriented at different angles

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INTERNATIONAL SEARCH REPORT

	onal Application No
	PCT/US 03/37059

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